SCIENCE

Vol. 80 — Friday, November 23, 1934 — No. 2082

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal

Lancaster, Pa. — Garrison, N. Y.

Annual Subscription, $6.00 — Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

CHEMISTRY IN THE SERVICE OF SCIENCE[1]

By Dr. A. T. LINCOLN

CARLETON COLLEGE

The approach to the Hall of Science at the Century of Progress is so arranged as to present to the visitor some of the concepts of the phenomenal development of chemistry as a symbol of the contribution of science to the human race. By means of the strikingly beautiful murals there is depicted the growth and development of chemistry and its applications to industry, commerce and medicine. It is the natural tendency for the individual scientist to believe that the particular branch of science in which his interest lies is of basic importance in its contribution to human knowledge and thereby to human progress. The chemist, however, can claim with some justice that in his field—chemistry—all the sciences find their common meeting ground. The chemist has to perfect himself more and more in mathematics as one of his most valuable tools. An eminent mathematician has said, "The striking progress in modern physics and physical chemistry has arisen from inquiries as to the data which specific mathematical tools could be made to yield when applied to physics and chemistry." He applies to his chemical problems the principles described by physics; he isolates, purifies and makes available for use the minerals and ores located by the geologist; he is now interpreting biological phenomena in terms of chemical changes and he is helping to pave the way for a clearer understanding and thereby a more accurate control over the physiological processes occurring in our own bodies. The automotive industry is really a chemical industry because everything used in it is chemical. This may be said of practically all the fundamental basic industries, a fact which further emphasizes the importance of chemistry as the handmaid of all the sciences.

Service to Astronomy

To the man in the street little connection is apparent between shaking the test-tube and star-gazing,

[1] Presented at the second annual meeting of The Minnesota Academy of Science, Rochester, Minn., April 21, 1934.

but the interrelation is nevertheless real and important. The progress of the astronomer is largely due to the help of the chemist and physicist. Nevertheless, the astronomer has himself assisted in the advance of these two closely related sciences.

Through the remarkable versatility of the spectroscope a wide variety of physical and chemical discoveries have been applied. Among these may be mentioned: (1) By pressure the shift toward red or violet spectral lines is utilized as a means of measuring the pressure of stellar atmospheres; (2) with temperature there is a variation of the relative intensities of lines which gives a clue to stellar temperatures. By the photometer, now displaced by photographic methods, the magnitude of tens of thousands of stars has been determined. The thermopile, radiometer, interferometer and photocell are among the many instruments that have contributed to a much completer knowledge of the stars.

Among the special contributions of the chemist are the new dyes, new alloys and new glasses which the astronomer is continually requiring for the more refined features of his researches. The dyes are not the variety that graces our dinners or ballrooms, but dyes that will improve the sensitiveness of the photographic plate in various wave-lengths, especially in the infra-red. A new dye has recently been discovered which makes it possible to prepare infra-red emulsions of higher speed than hitherto. They are sensitive to the region of 7,500 A° to 8,600 A°, much beyond the range of visible light from about 3,900 A° at the violet end to 7,600 A° at the extreme red, through rendering exposure of 1/100,000 of a second common, and even 1/1,000,000 of a second are frequently used, while a special dye, xeno-cyamine, gives a sensitivity up to 11,000 A°. What with a combination of the telescopic lens and a sensitized emulsion, infra-red photography makes possible photographs of mountains to a distance of over 300 miles and at sea removes the fog hindrance to good pictures. Infrared photography of the heavens as a supplement to the existing methods presents great possibilities. With infra-red filters a record of stars that radiate this light may be made while cutting off the visible spectrum and reducing the scattering of their rays on their way to the earth.

New alloys while useful in every industry are aiding in the progress of astronomy, wherein they are used for telescope mirrors, optical gratings and in many other ways. This demand for bigger and bigger telescopes is being met by the glass-maker, who is producing the glass of the desired composition to reduce expansion and contraction to the minimum with changes of temperature. Telescopes focus the object by means of a reflecting mirror at the bottom of the telescope tube. This glass disk is silvered on the accurately ground paraboloidal front surface.

The big 60-inch mirror, 8 inches thick, and weighing about one ton, has been superseded by the 100-inch mirror, which is 13 inches thick and weighs nearly five tons. And now within the last week or so a new 200-inch disk has just been poured of Pyrex glass, which is intended for the new reflecting telescope at the California Institute of Technology. Since expansion and contraction of glass with change of temperature changes the figure and decreases the definition of stars, use is being made of fused quartz, the coefficient of expansion of which is very small. These disks up to 12 inches in diameter are being utilized.

These are some of the numerous problems that the chemist has been asked to assist in solving, and the possibilities in the future for additional contributions of the chemist are possibly even greater.

SERVICE TO BIOCHEMISTRY

One of the fields of science in which the service of chemistry is extensively utilized is that of biological sciences and so intimate is the interrelation of the two that their joint activities have been designated by a combination of the two terms into a single word—biochemistry. As biology has been divided into two divisions, botany and zoology, which includes physiology, so the service of chemistry to these sciences is designated plant biochemistry and animal biochemistry.

Plant biochemistry: Hardly a phase of plant development can be considered but that the problems involved become highly chemical in character. The chlorophyll which is sometimes designated "the president of the powerful photo-electrical system" through the energy of the sun by a process designated as photosynthesis causes various chemical reactions with the liberation of oxygen as one of the by-products.

For work on this green coloring material of plants honors have recently been conferred upon two great chemists: Richard Willstätter, a noted German worker, to whom was given the Willard Gibbs Medal, and James B. Conant, an American chemist, who was recently elevated to the presidency of Harvard University. Many others have worked with this complex chemical of such fundamental importance to all life. A complete formula has been worked out only within the last few years, and even yet not all the atoms and bonds are located beyond dispute.

The hemin or red coloring matter of the blood is closely related to chlorophyll, and was probably derived from it ages ago. It has iron in place of the magnesium of the chlorophyll. Willstätter recently stated the principal characteristic of animal chemistry

as oxidation, catalyzed by the magnesium of the chlorophyll. With the aid of the chlorophyll granules in plants, employing the energy of sunlight, carbon dioxide is converted into sugar and from that into starch and cellulose—food, reserve food and structural materials, respectively. Animals ultimately subsist on plants, which in turn utilize the service of chlorophyll. "It may not be too much to call chlorophyll the most important organic chemical, for it has made life, as we know it, on this earth." Within the chloroplast wonderful chemical changes take place—starch is formed in some cells, while others are charged with sugar. Accompanying these there is possibly the flux of nitrogen and formation of proteins. Then associated in family connections are the carotenoids, the chlorophyll-phytol seeming to be a derivative of carotene. The pale yellow oily substance derived from carotene is our vitamin A, which the chemist now knows how to manufacture.

The impetus biology has given organic chemistry recently is demonstrated in a number of fields. The attempt to elucidate the structure of vitamins A and C and cognate problems is perhaps one of the most striking. The relation of vitamin A to natural polyene pigments of the carotene and related groups, which have been considered biochemical, now becomes purely a chemical problem of outstanding interest and is treated at present as such. Vitamin C has recently been identified with ascorbic acid and the structural formula assigned.

The mechanism of the intake of minerals by the plant root cells, which are able to maintain within the tissues a higher salt concentration than exists in the surrounding medium, involves problems well within the range of the physical chemist. The assimilation of nitrogen, the intake and effects of potassium as well as of phosphorus, not to include the secondary plant nutrients boron, copper, iodine and sodium, are fascinating chemical problems yet unsolved. The chemistry of plant juices is receiving marked attention from the latex of the rubber plant and the turpentine of the pines to the important classes of volatile essential oils. The extensive problems of plant breeding involve the formation and distribution of certain plant constituents.

Then the plants from which are derived our medicinal drugs comprise another fruitful field of chemical research, not to emphasize the control of the diseases and particularly the elimination of the enemies of plants by the preparation of insecticides, germicides and fungicides which have specific properties, particularly their harmlessness to man. The development of pyrethrum poisons is a conspicuous example.

Animal biochemistry and medicine: To follow animal as well as plant metabolism is one of the most fascinating of the chemist's tasks, as there is thereby afforded infinite opportunities. While biochemistry is at present becoming a mere name, this field is one in which the worker must have clinical as well as thorough chemical training, for it lends itself to an exercise of the imagination which is almost infinite, but a strong guard will have to be exercised over this fancy.

One of the great services of chemistry to biology and medicine is the protein research resulting largely through the work of Fischer, Kassel, Osborne and Sörensen in the discovery of the thirty-odd amino-acids, the building stones of the proteins. More recently the applications of physical chemistry have resulted in the outstanding contributions through the use of physico-chemical methods to this most complicated and important field.

The whole animal kingdom depends for the production of the amino-acids upon their synthesis by the plant cell. Hence animals depend for these vital proteins upon the plants which produce them through the photosynthetic process. The number of theoretically possible protein compounds that might be synthesized from the 31 amino-acids is almost limitless, but each protein has its biological reactions that characterize the particular species and distinguish it from all others. This specificity is practically limitless, and it is perfectly marvelous that nature always does manage to synthesize the same protein time after time through generation after generation of plants, a given organism reproducing its own characteristic patterns with never a variation, even in all members of the species. This is an impressive illustration of the exactness of the regulation of the vital reactions in nature.

The interrelations between the amino-acids, the numerous types of proteins, nucleic acids, the digestion and metabolism of proteins comprise one of the important fields in which the problems are becoming purely chemical in character. Their solution requires the methods of that branch of physical chemistry termed colloidal chemistry. This may be emphasized by two recent marked examples—that of the study of epilepsy and of insanity, both of which are problems in the colloid chemistry of the brain cells. In the study of epilepsy Irvine McQuarrie has recently emphasized that "as a general rule, the factors which tend to increase cell membrane permeability (superhydration) are those recognized as favoring the occurrence of epileptic seizures; whereas those which are thought to decrease permeability (dehydration) favor their cessation—the mineral and water balances in relation to the occurrence of epileptic convulsions are tentatively interpreted as indicating the existence of an inherent defect in the physiological mechanism

for regulating the semi-permeability of the brain cell membranes."

Claude Bernard's theory of anesthesia and narcosis as developed by Wilder D. Bancroft indicates that coagulation produced by certain drugs is counteracted by the peptizing effect of the compounds such as sodium thiocyanate on "the coagulated protein colloids of the central nervous system including the brain and spinal cord and the sympathetic nervous system." Bancroft suggests "that many of the 'functional disorders' may be nothing more than an abnormal degree of dispersion of the nerve colloids," and certain effects show "that such colloidal reagents will produce symptoms that are not unlike many of those of insanity." It has been shown that "coagulating agents cause changes in the brain colloids from normal through irritability and insanity to sleep, anesthesia and death. Dispersing agents cause changes in the brain colloids from normal, through insanity to death."

The problems presented by photosynthesis, action of infra-red radiation, catalysis due to minute quantities of elements, such as magnesium in chlorophyll, and the realization of the existence of complex colloidal systems in the various organisms lend added interest to the fascinating problems of biology and medicine, which chemistry is aiding in solving. The first stages of cooperation are soon followed, however, by the pure problem of synthetic organic chemistry and the application of physical chemistry.

In addition to the few problems mentioned above, many others of great interest are crowding to the front for solution which include the verification of the identity of calciferol with the naturally occurring vitamin D, the precursor of which is the irradiated ergosterol with antirachitic properties; glandular secretions; and the long lists of important local anesthetics, hypnotics, antiseptics, as well as the bactericides, and the interesting dyes which have specific toxic action on enzymes and on the catalytic activities of tissues—all of which offer almost unlimited scope to the organic chemist.

Bacteria and yeasts: There are two groups of biological operators which during their life processes produce enzymes which are definite chemical products some of which are recognized toxins and others antitoxins. The relation of these through their chemical reactions is assuming greater importance. This is due to the fact that apart from their medicinal values both of a curative and also of a poisonous character there are multitudes of bacteria and yeasts that can be cultivated and utilized in the production of chemical compounds. These include the nitrifying bacteria that convert nitrogen into compounds usable by the plant, the various processes such as the souring of milk, the manufacture of cheese and the preparation of silage, as well as the disposal of sewage; and the use of yeast in bread-making as well as in the fermentation of sugars. These fermentation processes are assuming great importance in the chemical industries for the manufacture of acetic acid, methyl and ethyl alcohol as well as many of the higher alcohols and ketones.

Service to Geology

The period of discovery of the location as well as the classification of the metallic and non-metallic constituents of the earth is nearly closed. This has been geology's large contribution. The evaluation of these deposits by the analytic chemist is a service readily recognized. Then there has followed the application of physical chemistry to the solution of the intricate problems of the origin of the various deposits such as van't Hoff's classic researches in the Strassfurt salt deposits and the more recent phase rule studies of the Trona Lake salt deposits and the recovery of potassium chloride therefrom. The origin of ore deposits and the availability of the values contained therein of metals as well as of the non-metallic deposits such as salt, gypsum, aluminum compounds, asbestos, clays and those materials usable in the preparation of abrasives, refractories and insulators, emphasize the intimate relationship of chemistry to economic geology.

International relationships may be affected by the distribution of the deposits upon which the activities of the nation may depend in peace as well as in war. For the independence of her industries the United States has practically all the minerals and industrial raw materials that would be needed even in time of war, except possibly asbestos, graphite, nickel, antimony, cobalt, potassium, chromium and platinum, whereas many nations, such as Germany, have few of the real essentials or "key" minerals and are therefore dependent upon foreign nations for these.

The nitrogen industry is a good illustration. Prior to 1914 practically all the nitrogen needed by the nations of the world was obtained as Chile saltpeter, sodium nitrate, from the Chilean government. During the war the supply required by Germany for her fertilizers and the manufacture of explosives was cut off completely. She developed a process for the fixation of atmospheric nitrogen and thus became independent of all the nations. Practically all nations are now drawing their supply of nitrogen from the air and the Chilean government, having depended largely upon the Chile saltpeter for the governmental revenues, is now in a critical financial condition due to the loss of its nitrate export trade.

In 1933 the world's production of synthetic nitro-

gen was 1,700,000 metric tons, or 50 per cent. less than the total production capacity for all forms of fixed nitrogen. This was 80 per cent. of the peak of 1929 production and 90 per cent. of the peak of 1929 consumption.

This development has been largely at the expense of Chilean nitrogen, which was 70,800 metric tons for 1932–1933, or only 15 per cent. of the 464,000 metric tons produced in 1929–1930 and only 4 per cent. of the production of all forms of nitrogen in 1932–1933. The excess Chilean nitrate stock is at least equivalent to a two-years' requirement. Agriculture theoretically should consume enormous quantities of nitrogen, but the rich soils of our midwestern plains and elsewhere will maintain a normal rate of production of grain for years to come without the aid of commercial fertilizers. A fertilizer is only a necessity under intensive cultivation, and the large proportion of the 400 million acres of crop lands is not so cultivated. It is evident that the time when an enormous quantity of nitrogen must be used is doubtless much further distant than has been indicated by propaganda put out during the past lamented "New Era."

In the petroleum industry the interrelationship of the geologist and chemist is most marked. The geologist has located a large number of the principal petroleum fields, and the survey has been so thoroughly done that he is practically at the end of his trail. The crude oil has been handed over to the chemist for refinement and synthesis of a multitude of new products and a potentiality of many others, the research work in this direction having hardly started. The United States production of 851 million barrels of 42 gallons each represents about 62.1 per cent. of the world's production. From this approximately 17,000 million gallons of gasoline were produced in 1931. The efficiency in this cracking process has meant an increased yield of some 300 per cent., within the last few years. More advance has been made in the quality of lubricating oils, of which about 1,200 millions of gallons were produced in 1931, to fulfil the ever-increasing stricter requirements of the rapidly moving parts of machinery, such as airplanes, steam turbines and spindles, than during the previous 30 years. The multitude of new compounds being produced has added hundreds of new words to our vocabulary. These substances are replacing the older solvents, and new uses for them must be found. New plastic materials are being produced in larger quantities; new synthetic resins for the paint and varnish industry are being developed, while 4,000,000 gallons of alcohol are produced yearly from the oil industry, whereas a billion could be produced in direct competition with agricultural production from molasses, potatoes, sugar beets and corn. Then there is the recent successful attempt by England to produce synthetic motor fuels by the hydrogenation of coal in direct competition with the petroleum industry.

Service to Agriculture

The chief business of chemistry in its relation to agriculture has been "to make two blades of grass grow where one grew before." For nearly the last hundred years the fundamental idea has been prevalent that the human race would disappear through starvation. Malthus predicted it, as did also Sir William Crookes, who prophesied we would not be able to grow enough wheat to sustain the human race. But now we hear on all sides that "too much food is being produced at prices too low to maintain the farmers, etc."

By the extensive research that has been carried on during the past fifty years, the growth of plants as well as animals has been chemically controlled. By balanced rations they have been properly fed and nourished. By breeding the protein content, the oil content or the starch content of wheat, oats, corn and other crops have been improved in such a way that their quality for various specific purposes has been greatly improved. Through proper fertilization and controlled conditions of growth, extra yields have been enormously increased.

Likewise the breeding of stock—horses, cattle, hogs, sheep—has been so developed as to produce better horses, better milch or beef cattle, better pork with the proper distribution of fat and lean in the bacon, as well as hens that will have a laying capacity of 300 eggs or more per year.

Not only have these conditions all required their special chemical controls, but both plants and animals have had to be very carefully protected from disease. This protection is a highly specialized field of chemistry in which by the development of various insecticides, germicides, fungicides, bactericides and disinfectants a strenuous warfare is being carried on for the preservation of the plants and animals. As we have seen in the realm of medicine, chemistry is the chief handmaid, as it were, in this never-ending fight. For the apparent increase in the enemies of both plants and animals, the grasshopper plagues, the impending chinch bug invasion, the menace of the cornborer and numerous other pests indicate that the victory is a long way from being won.

Natural versus synthetic products: As indicated, the chief purpose of agriculture has been the production of food for the human race. Now that that object can be so easily attained and there can be produced such a superabundance of food products, the questions arise: What is the farmer going to pro-

duce? What is he going to do with his land? The AAA says, "Take the land out of production," but does not go much further; yet Secretary Wallace does tell us that by the removal of 20,000,000 acres of land from the production of cotton there will be some millions of the inhabitants who will have to be removed from these lands and transported to some other more favorable section of the country, while the land they leave will revert to government parks to be visited by the traveling public in search of pleasure grounds. The few inhabitants residing there will have as their occupation the selling of gasoline, sandwiches, candy bars and hard liquors. The same picture presents itself with reference to the removal from active cultivation of wheat land, corn land, pasture land, since the reduction of production of these crops and the decrease in the cattle and hogs will further decrease the demand for land on which to produce these various products. This is not a very pleasant prospect for the land owner nor for many others.

Farm Products as Potential Raw Materials for the Chemical Industry

Cotton has been for many years one of our principal textile materials and some 17 million bales of 500 pounds each have gone each year into the production of cloth of various kinds and for numerous uses. But even this had to be processed by the chemist, according to certain washing, bleaching and dyeing processes. With the development of the tire industry more of the cotton fiber has gone into cordage for the construction of tires. Some of the poorer cotton fiber known as "linters" went into the manufacture of explosives like nitrated cotton. Now much more of it is being utilized by various synthetic processes for the preparation of rayon and a new type of paints or lacquers such as Duco, and particularly in the plastic industry. Then from the seeds there result hulls and meal utilized as feeds and fertilizers, the cotton seed oil which is used as edible oils, such as salad oils, the hydrogenated products such as Crisco, and for the manufacture of soap, a by-product from which—glycerine—has many uses, particularly as a basic material for the production of explosives (nitroglycerine), medicine, anti-freeze and synthetic resins (glyptal) used in the preparation of enamels and varnishes and plastics.

Similarly, corn, which was chiefly grown for feed, is now becoming the basis of a larger number of commercial products, such as starch for the textile trade, corn oil, a salad oil, dextrines for paste, corn syrup and many others. Then there is the cellulose of the corn husks and stalks, a potential material for paper pulp and building insulating boards; and the zein of the corn silks, a vegetable protein resembling cellulose, insoluble in water, with potential uses in the plastic industry.

From oat hulls there has been developed an important chemical solvent, furfurol, from which an important type of plastics is prepared in large quantities for the manufacture of victrola records and similar products.

New crops: By improved breeding the sugar content of sugar beets has been greatly increased, thus making them a competitor of sugar cane in the production of sugar. There are a number of possible new crops that are potential sources of chemical raw materials, such as soybeans, the oil from which is becoming a strong competitor of other oils used in the paint industry. "The diversity of industrial uses to which its several derivatives are already put is little short of amazing." In 1931, 2,226,000 acres of soybeans were used for hay, and 1,271,000 acres produced 18,885,000 bushels of seeds, and over 13,000,000 pounds of oil, against the approximate 9,000,000 pounds imported, which was about 50 per cent. of the importation of the previous year (1929).

Levulose, one of the digestion products of sucrose (cane sugar), is a valuable food, one and a half times as sweet as cane sugar. Its use promises marked benefit to the health of mankind as a preventative or a treatment of diabetes. It occurs in many plants and particularly in the weed, the Jerusalem artichoke or wild sunflower, to the extent of 8.64 per cent. to 19.47 per cent. The average in Iowa is about 14 per cent. and in Minnesota ranges from 6.72 per cent. to 10.3 per cent. With breeding this can be greatly increased, as has been demonstrated. An experimental plant for the production of levulose is in operation at the Iowa State College of Agriculture at Ames, Iowa.

The tung-oil trees are suited for producing paper, and ramie or China grass offers the strongest natural fiber for clothing and paper. The long leaf and loblolly pine in ten years are suited for pulp. The hybrid poplar produces short pulp fiber. There are large varieties of nut trees, fruit trees, vegetables, sweet potatoes, peanuts and many others, the cultivation of which can be greatly extended for the production of food. By new processes the chemist is busy with research on these new products so as to make them a valuable source of revenue to the farmer and to give him new opportunities by providing him with new crops. This results in broadening the old-time farming into a new agricultural industry—"the growing of chemicals through biological means and to chemcial ends."

In 1900 there were 20 million horses employed and in 1921, 21 million, but in 1931 there were only 13 million or a loss of 8 million horses in eleven years

due to the change from horse power to gasoline. This elimination of the horse reduced the consumption of food farm products equivalent to the food consumption of 40,000,000 people. An apparent advance in the technology of farming caused an immediate direct result, the greatest disaster that could have happened to the farm.

Then, too, by using 27,000,000 automobiles, the American people, instead of walking and using their own energy, consumed 15 per cent. less meat per capita in the same period, with the result that the number of cattle decreased in the United States from 40 million head in 1920 to 30 million head in 1931. These 10 million cattle, which have been lost, annually would consume as much food as 50 million people. There was during this period a loss of about 17 per cent. in the demand for farm products. The present use of automotive power means that approximately 20 per cent. of all farms in America are no longer needed, and if no control is applied the next most probable state of the American farmer will be even worse. The value of the American farm has, according to the United States Department of Agriculture, gradually decreased according to the index number of 156 in 1921 to 116 in 1929 to probably as low as 70 in 1932.

By individual technology the farmer has not strengthened his position financially, since between 1910 and 1931 he purchased seven billion dollars worth of automobiles, trucks and tractors. These were not bought from his income, for farm mortgages increased during that same period eight billion dollars. The outstanding debt against their equipment remains, and about 90 per cent. of the equipment itself has reverted to rust and decay.

Stated in another way: Only 200 million acres, instead of the 350 million acres now under crop cultivation in the United States, are necessary to furnish all the food and raiment that all living things in this country require. This excess acreage is largely inclusive of what is termed submarginal lands or land incapable of yielding an average crop without entailing a large expense. William J. Hale says:

> It is needless to recall the many panaceas proposed for the farmers' ills or to recount the many acts of congress carrying appropriations of billions of dollars, designed to ameliorate his sufferings. All attempts thus far in governmental action have come to the same sad end—failure; and all future attempts, eliminative of chemical and biological direction, are destined to the same untimely end. There can be only one practical solution—scientific management with financial assurance of real contracts. Those who would promote the greatest industry that Heaven can ever give to mortal man must rid themselves of all political and fantastic taint; they must envisage here a chemical industry operating biologically for the betterment of society.

THE CHEMICAL INDUSTRY

To fulfil the requirements of the various industries for chemical aid in the development of their special interests the necessity for chemical control has so increased that these various fields have virtually become specialized departments of applied chemistry with the chemist and his process in full control. This has meant that the fields of chemistry have become more extensive, that they have been developed to a greater depth in order to solve the numerous new problems which call for hosts of new materials with specifically designated properties increasing more and more in rigid specification. This has resulted in chemistry building up the materials for the various industries resulting in the development of the new chemical industry which is becoming bigger and bigger and assuming more and more importance in the development and advance of our civilizations.

Machine production has been such an economic force that it has moved our very social and political foundation. Chemical production is a new factor in our industrial economy that up to the present has been almost completely overlooked. It has increased enormously since 1920, while mechanical energy used in manufacturing since 1909 has really declined. This indicates that the humming wheels of the machine age are slowing down as the decrease in the use of power during the past half century has lost much of its initial momentum. Mr. William Haynes has recently emphasized the fact that when the first effects of the industrial revolution felt in America in 1790 were recognized, about 15 to 39 horse power each from the water wheels was the sole source of industrial power, and the total population of 4 million consumed about 70,000 horse power distributed through 3,500 mills. In 1870 the total horse power used in all factories, mines and for transportation was nearly 7 million or 100 times as much for a population of about 38 million—that is, the mechanical energy per capita had increased 10 times. Since 1870 the increase has been only about 5.6 times. The rate of increase reached the peak in 1909. From 1866 to 1889 the increase was 54 per cent., from 1889 to 1899 it was 39 per cent., from 1899 to 1909 it was 53 per cent., from 1909 to 1919 it was 35 per cent., and from 1919 to 1929 the increase had fallen to 25 per cent. During this last period 1920 to 1930 there was an actual increase or gain of 1,280,000 workers in our manufacturing industries. The horse power from 1914 to 1927 consumed in all industries increased from 22 to 38 millions, while the chemical industry increased from 992,703 to 1,840,049 or nearly double the gain of the national all-industry average. The value of the all-in-

dustry products was increased from 34 billions to 62 billions, while in 1914 the value of the American chemical products was $1,299,085,000, and in 1929 that had increased to $3,315,228,000. That is, both the value of the goods produced in our chemical industries and the energy consumed have increased nearly 3 times against the all-industry increase of only twice.

In the industries to-day the development of chemical operations has reached the point where none of our factories can operate without chemicals. In a few cases we have emphasized this as in the case of agriculture which is dependent upon fertilizers and insecticides, and the textile industry which requires bleaching materials and dyes. These examples could be greatly extended, to say nothing of transportation, communication—the telephone, telegraph and radio—medicine, the electrochemical industry, and even the arts—all must have their essential chemical supplies.

As gunpowder disrupted the seemingly impregnable alliance of kings, barons and bishops which sustained the feudal system; just as the machine inaugurated the industrial revolution which opened up such vast resources for production, so chemistry is moving the foundation of our present system. "The chemical revolution will bring lower costs, a growing multitude of new products and the increasing replacement of familiar wares by superior synthetic articles." The chemical revolution will make possible greater and broader consumption which will "enable us to transcend splendidly the progress of the past century."

OBITUARY

GILMAN A. DREW

1868–1934

THE death of Gilman A. Drew at his home in Eagle Lake, Florida, on October 26, after a lingering illness, will recall to the minds of American zoologists first of all the great services that he rendered to their science by his work at the Marine Biological Laboratory over a period of twenty-five years from 1901 to 1926. At the end of that time ill health forced him to give up his work at Woods Hole, and he retired to his orange grove in Florida. He was active in the work of his grove and in connection with agricultural affairs in Florida until about two years ago.

Drew was a student of W. K. Brooks at Johns Hopkins University, and his assistant for two years after obtaining his Ph.D. degree in 1898. There he acquired his interest in mollusks and laid the foundation for his subsequent investigations. His publications were not many in number, but they were remarkable for their finished technique and accurate delineation and description. He had the mind of the naturalist rather than of the analytic experimentalist or philosopher; and he combined studies of anatomy, behavior and embryology in gaining a total view of the life history of the species under consideration.

His study of the breeding mechanisms and behavior of the squid, Loligo, is one of the most finished and complete studies of reproduction in any animal. In this he began with breeding behavior, which is faithfully described; and proceeded thence to an examination of the structure and mechanism of the extraordinarily complicated spermatophores of the male, the method of their use and their correlation with remarkable structural peculiarities of the female which provide a double insurance of fertilization. He described very minutely the manner in which a long series of structural and functional mechanisms of the reproductive apparatus of the male produce these beautiful adaptive structures, timed to discharge a fertilizing flow of spermatozoa long after their attachment by a special cementing segment on the appropriate spots of the body of the female. He shows in a most complete way how structure, function and behavior combine to produce the perpetuation of the species. If Drew had never done any other work, this alone would mark him as one of the really accomplished naturalists of his time. It is unfortunate that this work is not better known to students of animal behavior.

Drew was also a stimulating and resourceful teacher. He was professor of biology at the University of Maine from 1900 to 1911; but his best opportunity was in the course in marine invertebrates at Woods Hole, which he directed from 1901 to 1909. In the field trips he was one of the most active of all the party; in spite of his lameness, with his one powerful leg and his trusty crutch, no one could go farther or better than he on land, over boulders, or in the shallow water collecting. In the laboratory he was equally active. A book for students which he published on this subject has enjoyed a wide reputation.

Drew became assistant director of the Marine Biological Laboratory in 1909, and after two years he resigned his professorship in the University of Maine to devote his whole time to this work. It would be difficult to do full justice to the value of his services during the seventeen years devoted to administration, within which the great material developments of the laboratory took place. In the splendid modern buildings of the Marine Biological Laboratory the marks of Drew's minute supervision, ingenuity and in-

ventiveness are everywhere apparent; he was at once the architects' best collaborator and the investigators' chief reliance, in construction and equipment. He introduced and perfected the new system of accounting that the larger operations demanded, and was constantly at the service of investigators in the satisfaction of their multifarious needs.

Drew was an upstanding, unselfish, conscientious, uncompromising, energetic man, enjoying the confidence of all, and the affectionate regard of many friends. His election as president of the American Society of Zoologists in 1920 testifies to the respect of his confrères. His memory deserves perpetual preservation in the minds of American biologists.

FRANK R. LILLIE

RECENT DEATHS

DR. EDWARD RENOUF, from 1890 until his retirement in 1911 collegiate professor of chemistry at the Johns Hopkins University, died on November 14 at the age of eighty-six years. Dr. Renouf had been connected with the university since 1885, when he was appointed assistant in chemistry.

DR. ERIC VON FUELNEGG GEBAUER, organic chemist, of Gary, Ind., formerly assistant professor in the Medical School of Northwestern University, died on November 18, from inhaling hydrochloric acid gas, while carrying out an experiment in his laboratory. He was thirty-three years old.

DR. KARL RITTER VON LINDE, who developed the Linde process for the manufacture of liquid air, died on November 16, in his ninety-third year.

HENRY ATTWOOL ALLEN, formerly a member of the staff of the British Geological Survey, died on October 3 at the age of seventy-nine years.

SCIENTIFIC EVENTS

THE WAITE AGRICULTURAL RESEARCH INSTITUTE

AN account of the history and development of the Waite Agricultural Research Institute from the year 1925, when its activities first started, up to 1932 has been issued by the University of Adelaide and is summarized in *Nature*. Although the chief objective of the institute is to conduct research on plant and soil problems, it also provides an advisory service to the Department of Agriculture in plant pathology and entomology and gives specialized courses of instruction for the agricultural degrees in the University of Adelaide.

The scope of the scientific work undertaken at the institute covers a wide field. As might be expected, the limited rainfall and the development of a system of cereal and grassland management to suit such conditions forms one of the major problems, and a study of the water requirements of plants under various manurial treatments and the differences exhibited by improved varieties of cereals and leguminous plants in this respect has led both to increases in yield being obtained and also to the extension of the area capable of supporting the crop. Pasture problems are being investigated both from the agricultural and the chemical point of view, special attention being paid to their mineral content and improvement by means of the introduction of superior species and strains.

Survey and classification of the various soil types in Australia forms a further branch of the work in the chemical section, and fertility problems, particularly in the irrigation settlements, are also being investigated. Entomological work has only been in progress since 1929, but already much valuable information has been obtained with regard to various pests of pasture, cereal and orchard crops. Diseases of agricultural crops inevitably form an important branch of the work of the institute, and deficiency diseases due to a lack of some mineral element have also been successfully investigated. Breeding experiments with the view of securing varieties with improved resistance to fungus diseases form a natural corollary to the work of the plant pathology section.

Besides the land devoted to agricultural experiments, a certain area is reserved as a permanent park. Advantage has been taken of this to plant a portion as an arboretum, one section being used for indigenous, and another for introduced, species. The report includes a list, with abstracts, of the one hundred and forty-one papers published from the institute during the years under review.

ELM DISEASE IN GREAT BRITAIN

THE London *Times* writes: "The conclusion this autumn of the seventh annual survey of the elm disease permits a review of the extent of attack by this insidious and at times highly virulent malady of the elm genus." During the past summer the disease has made definite progress in nearly every area examined, but the severity of attack is still below that of the peak year, 1931.

Infected trees have been recorded in three new counties, Lancashire, Merionethshire and Cornwall. If the counties of England and Wales are classified according to severity of attack the following position is

found: Frequent and often serious, 9; sporadic, 16; seldom found, 16, and disease not reported, 11. A more wide-spread survey would almost certainly add to the numbers in the classes "sporadic" and "seldom found."

The first class, in which the disease is frequent and often serious, includes only nine out of the 41 counties where it is known to occur, and with one exception—the Isle of Wight—these lie to the east and north of London. There is no indication as yet of any tendency for the disease to extend its virulent range westwards. Severe local outbreaks do occur, but they are usually very restricted, and over the greater part of England it is doubtful if the casual observer would be aware of the presence of the disease.

The progress of those trees in which evidence of continued die-back is no longer visible is being carefully watched, according to the *Times*. The number of such "recoveries" is still large, but the fungus usually remains dormant in the wood of the branches. A renewed onset of the disease has already taken place in some of these trees, so that recovery is by no means assured. A limited number of cases are known where all trace of the fungus has gone and the tree appears perfectly normal.

With regard to preventive measures, lopping is only successful if the disease is taken at a very early stage, and even then there is always the possibility of reinfection. Apart from the removal of dead and fallen trees, successful measures have not yet been devised for keeping in check the elm bark beetles, which act as chief carriers of the disease.

Although there is still no definite record of the elm disease in Scotland, some laboratory work has been done on the sickly elms found during last year's survey in that part of the country. Various fungi have been isolated, and work on these is proceeding.

CENTER FOR POLAR RESEARCH AT CAMBRIDGE, ENGLAND

ACCORDING to a wireless dispatch to *The New York Times*, the new center for polar research was opened at Cambridge, England, on November 16 by Stanley Baldwin, Lord President of the Council, in the presence of many veteran Arctic explorers.

Designed as a memorial to Captain Robert Falcon Scott and as an information center for future explorers, the new building will house the School for Polar Research, which has been in existence at Cambridge for several years. In the words of the director, Professor Frank Debenham, it will make exploration "easier, less expensive and more valuable."

Mr. Baldwin said in part:

> This building has been erected as a testimony to aspirations common throughout the world—a desire for adventure, knowledge and research into the secrets of nature.
>
> Every continent and island in the world has its own tales of heroism and fortitude—tales which have come down from generation to generation to stir the hearts of men. Names like Frobisher, Hudson, Perry and Franklin are still a trumpet call to all those whose heart-strings vibrate to the inner call of adventure.
>
> In the South the two names of Shackleton and Scott stand out supreme, but let us never forget the many others whose names have not lived after them, but whose courage and endurance were as great. Arctic and Antarctic exploration is a prolonged war which needs strategy and carefully laid plans for its successful prosecution. The new building provides a venture in study and research for all those going out into the partly known and unknown.

On the front of the building is a bust of Scott executed by his widow. Above it on the frieze are the words, "Quaesivit Arcana Poli Videt Dei"—"He went seeking secrets of the Poles and he sees God." In the forecourt stands a symbolic statue given by Lady Young as a memorial to the five who died with Scott on his last strategic expedition, among them Captain Oates, "a very gallant gentleman."

The facilities of the building include a library, map room, research room, museums and archives containing all available log books, diaries and weather records kept by polar expeditions.

Polar veterans who attended the dedication ceremony, according to the *Times*, included Dr. Jean Baptiste Charcot, leader of two French expeditions to the Antarctic; Dr. Ejenar Mikkelson, Danish Greenland explorer; Admiral Sir George Egerton, who first went to the Arctic almost sixty years ago; Daugard Jensen, head of the Greenland Administration Board; Vice-Admiral Sir Reginald Skelton, chief engineer of Scott's first expedition, and others who served under Scott or Shackleton in Antarctic adventures.

RESEARCH IN ENGINEERING AT HARVARD UNIVERSITY

THE following is a list of some of the more important contributions which the Harvard Engineering School has recently made through its research activities as given in *The Harvard Alumni Bulletin:*

(1) The investigation of the properties of steam as part of a rational project, with the experimental work carried out in three institutions. This work has been accepted and is now in course of being embodied in the international standardization of accepted values for the properties of steam. It has been the basis for the design of modern high-pressure and high-temperature steam machinery.

(2) The investigation of fans for mixing large vol-

umes of air. This has been an exploration in a field of great technical importance, but of little exact knowledge. The work already done has had considerable influence on existing practise.

(3) Studies of dielectrics and high-voltage cables. These have led to the discovery of new laws relating power loss and power factor to voltage, frequency, and temperature in dielectrics; and to the determination and rationalization of the laws of ionization loss in high-voltage cables. As a result of these researches, improvements in manufacturing and in testing dielectrics and high-voltage cables have occurred, and the life of properly designed cables has been materially increased.

(4) Fundamental studies of the flow of water through sand and other filtering materials. This work is aiding engineers in the exploitation of ground waters and in the interpretation of the behavior of water filters.

(5) Studies of the effect of corrosion on the carrying capacity of water pipes composed of different materials. These studies evaluate in hydraulic terms the destructive effects of water on the metallic conduits through which it is distributed.

(6) Studies of the factors governing the destruction of the complex organic substances contained in municipal wastes. These have paved the way for more economical design and operation of waste treatment plants.

(7) Studies of the control of dust generation in the construction industries (in cooperation with the School of Public Health). This work is leading to the development of non-hazardous drilling operation.

(8) Fundamental studies of age-hardening in steels and non-ferrous alloys; of the graphitization process in cast iron; and the hardness of the adjacent parent metal, and of the secondary and mosaic structure of single metal crystals. Work in the development of the "Reflex-Laue" method of x-ray crystal analysis. These studies have been of great importance to the metal industries.

THE MANGAREVAN EXPEDITION OF THE BERNICE P. BISHOP MUSEUM

The Bernice P. Bishop Museum welcomed on October 28 the members of the Mangarevan Expedition returning to Honolulu aboard the specially designed sampan *Islander* from six months' field work in southeastern Polynesia. The *Islander* brought home the natural history party: Dr. C. Montague Cooke, Jr., malacologist and leader; Dr. Harold St. John, botanist; Mr. Elwood Zimmerman, entomologist; Mr. Donald Anderson, assistant malacologist; and Mr. Raymond Fosberg, assistant botanist. Still at work in the field is the anthropological party, Dr. Peter H. Buck, Kenneth P. Emory and J. Frank Stimson, aboard the cutter yacht *Tiare Tahiti* which will be released at Papeete, Tahiti, about January 1.

The Mangarevan Expedition was organized for the exploration of little-known islands and atolls in extreme southeastern Polynesia. Of the thirty-one islands and many atolls and reefs on which the party landed, particular attention was given to Anaa, Napuka, Tatakoto, Hao, Mangareva, Timoe, Pitcairn, Henderson, Oeno, Rapa, Raivavae, Rurutu and Rimatara. Surveys supplementing those made by Bishop Museum in previous years were conducted at Tubuai, Tahiti, Raiatea, Huahine and Borabora.

The program of the expedition stressed investigations in botany, ethnology, malacology and entomology, with incidental attention to geography, geology and marine zoology—a procedure that guided the selection of the professional personnel and numerous assistants.

To gain access to atolls and cliff-bound volcanic islands a ship of high power and shallow draft was designed, and to permit the party to divide its forces for particular kinds of work a transfer ship and power launches were provided. The expedition was made possible by generous grants from the Rockefeller Foundation and from institutions and individuals in Hawaii.

Regarding the results of the expedition Professor Herbert E. Gregory, director of the museum, states that: "Under the experienced leadership of Dr. C. Montague Cooke, ably supported by Captain William Anderson, of the *Islander,* the program of the expedition was carried out with marked success. The collections, which include some 15,000 sheets of plants, 40,000 insects, 160,000 land shells and representative series of other animals, is sufficient to give a fairly complete picture of the land fauna and flora of the southeastern Pacific, and to indicate the relation of the oceanic islands to South America. The expedition practically completed the general survey of the ethnology and natural history of Polynesia which has been the chief interest of the museum since 1920."

THE INTERNATIONAL PHYSIOLOGICAL CONGRESS FUND FELLOWSHIPS

The International Physiological Congress Fund Fellowships were established by the Federation of American Societies for Experimental Biology following the session of the thirteenth International Physiological Congress in Boston in 1929. The committee for the congress presented the surplus of the funds collected, to the federation, with the suggestion (1) that if and when another International Physiological Congress was held in this country the principal be used for the promotion and support of that congress, and (2) that the income of this fund be appropriated triennially, in units of $250, to defray the expenses of promising young American workers in the field who would not otherwise be able to attend International Physiological Congresses abroad and who had creditable papers to read before the congress. Membership in the federation is not a necessary condition for the award of a fellowship.

The Executive Committee of the Federation announces four fellowships of $250 each to be awarded for the fifteenth congress to be held in Leningrad-Moscow from August 9 to 17, 1935. One fellowship will be awarded in each of the branches of biological science represented by the four constituent societies of the federation: namely, The American Physiological Society, The American Society of Biological Chemists, The American Society for Pharmacology and Experimental Therapeutics and The American Society for Experimental Pathology.

The conditions for the award of these fellowships in accordance with the vote of the Executive Committee of the federation are as follows:

1. Each candidate must be recommended as worthy by some member of the society representing the field of study or by some other individual familiar with the character of the candidate's work.
2. Candidates must be under thirty-five years of age and must not have yet attained professorial rank or its equivalent.
3. Each candidate must present with the application a draft of a meritorious paper to be presented to the congress.
4. Applications must be made before January 15, 1935, to the *Secretary* of the society which includes the field of study.
5. These applications will be considered by the councils of the respective societies, who will submit an approved list of nominees to the Executive Committee of the Federation.
6. Final selection of fellows will be made by the Executive Committee of the Federation.

Applications should be made to the secretary of the society in whose field the work to be presented at the congress lies: for *Physiology,* Frank C. Mann, Mayo Clinic and Foundation, Rochester, Minnesota; for *Biological Chemistry,* H. A. Mattill, State University of Iowa, Iowa City; for *Pharmacology and Experimental Therapeutics,* E. M. K. Geiling, the Johns Hopkins University; for *Experimental Pathology,* Shields Warren, Palmer Memorial Hospital, Boston.

SCIENTIFIC NOTES AND NEWS

THE Nobel prize in chemistry has been awarded to Dr. Harold C. Urey, professor of chemistry at Columbia University, for his discovery of deuterium.

ON the occasion of the celebration of the one hundredth anniversary of the founding of the University of Brussels, honorary degrees were conferred on a number of scientific men. These included the degree of doctor of medicine, on Dr. Karl Landsteiner, member of the Rockefeller Institute for Medical Research, and the degree of doctor of science, on Dr. George Van Biesbroeck, until 1915 a member of the staff of the Royal Observatory, Belgium, now professor of practical astronomy at the Yerkes Observatory. As already announced, the degree of doctor of applied science was conferred on Dr. Leo H. Baekeland, born in Belgium in 1863, now honorary professor of chemical engineering at Columbia University.

THE Saunders Gold Medal of the American Institute of Mining and Metallurgical Engineers for "outstanding achievements in mining" has been awarded to James MacNaughton, president and general manager of the Calumet and Hecla Consolidated Copper Company. The presentation will be made in New York in February.

AT a reunion of former students of the department of chemistry at the Ohio State University on November 17, presentation was made by the alumni of a portrait of Dr. William McPherson, professor of chemistry and dean of the Graduate School. The portrait, the work of Professor James R. Hopkins, of the faculty of fine arts, was presented by George A. Burrell, '18, consulting chemist of Pittsburgh, Pa.

A PORTRAIT of Professor Emeritus William H. Hobbs, formerly head of the department of geology of the University of Michigan, was recently presented to the university by the department of geology. The portrait is the work of Leon A. Makielski. A large group of colleagues, students and friends of Professor Hobbs attended the presentation ceremonies, which included addresses by Dr. John G. Winter, president of the Research Club, and Dr. Ermine C. Case, chairman of the department of geology. President A. G. Ruthven accepted the gift for the university, after which Professor Hobbs responded.

ACCORDING to *Nature* a complimentary dinner to Professor A. Fowler, since 1923 Yarrow research professor of the Royal Society, on his retirement after fifty-two years' association with the Royal College of Science, South Kensington, was recently held at the Imperial College Union. Dr. H. Dingle, assistant professor of astrophysics at the college, occupied the chair, and among the assembly, in addition to many old students and colleagues and the rector of the college, H. T. Tizard, were representatives of a number of scientific societies, including Sir James Jeans, president, and Professor W. W. Watts, president-elect, of the British Association; Professor F. J. M. Stratton, president of the Royal Astronomical Society; Professor H. H. Plaskett, Savilian professor of

astronomy, Oxford, and Professor Allan Ferguson, secretary of the Physical Society. Dr. Dingle and Sir Richard Gregory were the principal speakers.

RALPH E. FLANDERS, vice-president of the Jones and Lamson Machine Company of Springfield, Vt., has been elected president of the American Society of Mechanical Engineers.

AT a recent meeting of the Massachusetts Psychiatric Society Dr. C. Macfie Campbell, professor of psychiatry at the Harvard Medical School, was elected president.

AT a meeting of the New York Academy of Medicine on November 8 Dr. Eugene H. Pool, professor of clinical surgery at Cornell University Medical College, was nominated to the presidency for a term of two years to succeed Dr. Bernard Sachs, who presided. Other nominations, all of which will be voted upon at the next regular meeting, were Dr. Herbert B. Wilcox, *vice-president;* Dr. George Baehr and Dr. William S. Ladd, *trustees* for five years, and Dr. Sachs, *trustee* for one year.

AT the annual meeting of the Royal Society of Edinburgh the following officers were elected: *President,* Professor D'Arcy W. Thompson; *Vice-presidents,* Sir Thomas Holland, Professor C. G. Darwin, Professor R. A. Sampson, Principal O. Charnock Bradley, Professor P. T. Herring, the Marquis of Linlithgow; *General Secretary,* Professor J. H. Ashworth; *Secretaries to Ordinary Meetings,* Professor F. A. E. Crew and Professor J. P. Kendall; *Treasurer,* Dr. James Watt; *Curator of Library and Museum,* Dr. Leonard Dobbin.

PROFESSOR EDMUND S. CONKLIN, of the University of Oregon, has been appointed professor and head of the department of psychology at Indiana University. He succeeds Professor William F. Book, who has retired with the title of professor emeritus.

E. V. ELLINGTON, head of the department of dairy husbandry of Washington State College and Agricultural Experiment Station, was recently appointed vice-dean of the College of Agriculture and assistant director of the station.

DR. J. R. KATZ, of the University of Amsterdam, who has completed a special six weeks' course of lectures at Cornell University as the George Fisher Baker non-resident lecturer, has been invited to continue his lectures for the remainder of the first term. His subject will be "The Study of Substances of High Molecular Weight by Means of X-rays."

DR. ERNST FISCHER, of Frankfort-am-Main, has been appointed visiting associate in physiology at the School of Medicine and Dentistry of the University of Rochester, and Dr. Konrad Dobriner, of Munich, has been appointed research fellow in medicine.

DR. LOUIS B. BALDWIN, formerly assistant professor of medicine at the University of Rochester, New York, has been appointed physician-in-chief of The Desert Sanatorium and Institute of Research at Tucson, Arizona.

DR. GEO. OTIS SMITH, formerly director of the U. S. Geological Survey and from 1930 to 1933 chairman of the Federal Power Commission, has been elected chairman of the Board of Trustees of Colby College.

W. McK. MARTIN, formerly associate professor in the department of chemistry of the Montana Agricultural Experiment Station, has joined the research department of the American Can Company, Maywood, Illinois.

Nature reports that J. M. Edmonds has been appointed geologist on the staff of the Geological Survey, Khartoum, Anglo-Egyptian Sudan.

PROFESSOR DR. S. MITA, of the Tokyo Imperial University, will be appointed director of the new medical college of the Formosa Imperial University, at Taiwan, which will open in 1936, when it is expected that the building will be ready for occupancy. The present medical school in Formosa will be raised to the status of a university college of medicine.

DR. GEORGE R. MINOT, who with Dr. Murphy and Dr. Whipple was recently awarded the Nobel Prize in physiology and medicine, sailed for Stockholm on November 14.

REXFORD G. TUGWELL, Under-Secretary of Agriculture, returned on November 15 from Europe, where he has been traveling for two months. Dr. Tugwell was at the head of the American delegation to the recent Conference of the International Institute of Agriculture at Rome.

PROFESSOR G. H. PARKER, of Harvard University, gave on November 5 the annual address at the meeting of the Worcester Chapter of the Sigma Xi. The subject of his address was "Neurohumors: Novel Agents in the Action of the Nervous System."

THE annual Gross lecture of the Pathological Society of Philadelphia will be given on the evening of December 13 by Dr. Shields Warren on "Recent Advances in the Pathology of the Thyroid Gland."

DR. ULRICH FRIEDEMANN, formerly professor at the University of Berlin and director of the Division of Infectious Diseases of the Virchow Hospital, will give three lectures under the auspices of the Edward K. Dunham Foundation at the Harvard Medical School

at five o'clock on December 4, 6 and 11. The subject of the lectures will be "Problems Concerning the Pathogenesis of Infectious Diseases."

PROFESSOR W. M. THORNTON, the new president of the British Institution of Electrical Engineers, delivered his inaugural address before members of the institution on October 26 on "The Importance of Insulation in the Transmission of Electrical Energy."

THE department of botany of the Iowa State College and the Corn Research Institute of the Iowa Agricultural Experiment Station held on November 15 and 16 a symposium commemorating six decades of the modern era in botanical science at the college. The meeting commemorated the pioneer work of Professor Charles Edwin Bessey, who joined the faculty sixty-four years ago. Professor Bessey's compound microscope was on display. Two hundred botanists attended the exercises. Dr. Ernst A. Bessey, a son of Dr. Bessey, who is head of the department of botany at the Michigan State College, gave an address on the "Teaching of Botany Sixty-five Years Ago." On this occasion the honorary degree of doctor of science was conferred on Henry A. Wallace, Secretary of Agriculture, who was an honor graduate of the college in 1910.

THE American Board of Psychiatry and Neurology, as reported in the *Journal* of the American Medical Association, was organized at a meeting in New York, on October 20, with the following officers: Drs. H. Douglas Singer, Chicago, *president;* Charles Macfie Campbell, Boston, *vice-president,* and Walter Freeman, Washington, D. C., *secretary.* Other members are Drs. Lewis J. Pollock, Chicago; George W. Hall, Chicago; Franklin G. Ebaugh, Denver; Lloyd H. Ziegler, Albany, N. Y.; James Allen Jackson, Danville, Pa., and Adolf Meyer, Baltimore. A committee was appointed to consider plans for examinations, credentials and forms for application blanks.

THE Long Island College of Medicine has received a bequest of approximately $1,500,000, from the late Frank L. Babbott, who died in Brooklyn in December, 1933, for the establishment of an endowment fund, the income from which is to be applied to the furtherance of medical education and research.

THE Rockefeller Foundation has made a grant of $50,000 to the University of Chicago to carry on biologic research. This is an increase over the annual grant of $30,000 which the foundation has given to the university for the last five years. The additional $20,000 will be used to cover the expenses of the sex research program, which until this year has been financed by the committee on research in problems of sex of the National Research Council.

IT has been decided to publish all the papers presented on the occasion of the dedication of the Lilly Research Laboratories at Indianapolis in the form of a volume in which will be included an account of the laboratory and its activities. It is hoped that this volume will be completed and will be ready for distribution early next year. Copies will be sent to guests present at the celebration and to scientific and medical men who may be interested in securing a full report of the papers presented by Sir Henry Dale, Sir Frederick Banting, Dr. Irving Langmuir, Dr. Elliott P. Joslin, Dr. George R. Minot, Dr. Carl Voegtlin, Dr. George H. Whipple and Dr. Frank R. Lillie.

THE following awards have been made by the British Institution of Civil Engineers: Baker Gold Medal to Ralph Freeman, London. For papers read and discussed at ordinary meetings: Telford Gold Medals to Dr. J. J. C. Bradfield, Sydney, Australia, and to Ralph Freeman, London; Webb Prize and Telford Premium to W. E. Gelson, Delhi; Indian Premium to J. D. Watson, Lahore; Telford Premium jointly to Ralph Freeman, London, and Lawrence Ennis, London; Telford Premium jointly to E. F. Law, London, and Vernon Harbord, London; Manby Premium jointly to J. F. Pain, Winchester, and Gilbert Roberts, Margate; Trevithick Premium jointly to R. W. Foxlee, London, and E. H. Greet, Iver, Bucks. For papers published without discussion as "Selected Engineering Papers": Telford Premiums to E. F. Reid, London; jointly to F. W. H. Stileman, Weybridge, Surrey, and J. S. Young, Perth, Australia; to E. H. Bateman, Birmingham; to A. C. Gardner, Glasgow; to W. G. Morrison, London; to B. C. Hammond, Worcester; the Crampton Prize to G. M. T. Rees, Gerrards Cross, Bucks; the Charles Hawksley Prize has been awarded to H. G. Cousins, London, and the Coopers Hill War Memorial Prize to F. V. Appleby, Brighton.

DISCUSSION

MUSEUM CONDITIONS IN THE UNITED STATES

IT is the purpose of this article to present the results of a study of 134 museums of natural history representing a fair cross section of their distribution throughout the United States. The objective of the investigation was to evaluate the museum method of education among the people of this country. Althoug

there is no certain way of measuring the social value of museums we are able to approximate it by a study of their activities, these data being necessarily obtained by questionnaire.

The museums are found to be irregularly distributed among the states, their geographical center being approximately one hundred miles southwest of Chicago. Although Massachusetts, New York and California lead in number of museums per state this is deceptive in any just appraisal of the attitude of the people toward museum work. Factors which appear later will diminish the apparent importance of the states mentioned. When the distribution of these museums is charted on a map in various shades of gray a simple diagram showing the spread of museum interest is produced. With few exceptions it is surprisingly similar to a map of civilization in the United States, by Huntington (1924). On the museum map the Gulf coast and the Mexican border appear to be more enlightened, and the northern Rocky Mountain area less enlightened, than Huntington indicates. Although the museum map represents only one criterion in such a social study, it is of considerable interest to note how closely it resembles that produced by the assemblage of many criteria.

The first factor to be introduced in approaching a real picture of museum conditions is population; and this shows that a few New England states, the states of the High Plains and the West coast, lead in number of museums per population, a no small factor when we disregard economic conditions and consider only the interest that people take in museums.

Then again, if we study the museum situation with reference to educational activity we arrive at a somewhat different picture. The activities of a museum may be listed as exhibition, discovery, research, lectures, publication and school service. In a general way they indicate the energy expended by museums and if plotted in map form result in a very irregular dispersal throughout the country, Pennsylvania and Illinois being leading states. The distribution of activity could not be drawn in sweeping areas, as was the case in plotting the number of museums per state. The energy or educational activity map not only indicates the museum interests of the population, but it also shows the breadth of educational scope and to a certain extent the quality of the museums.

If we now prepare a map based on elements produced by computing the state averages of activity relative to the population of states we have a picture of the United States showing their qualitative relation to each other in the appreciation of the museum method of education. The results are extremely surprising and might even cause embarrassment to some of the wealthiest centers of population. Those states which are doing relatively the most in a museum way are Vermont, Rhode Island, North Dakota, South Dakota, Colorado and Arizona. To their credit they far outshine their immediate wealthy neighbors. States of intermediate classification are Maine, Connecticut and South Carolina. Astonishing as it may seem, among the states of low recommendation we find Massachusetts, New York and California, those very ones which lead in numbers of museums. In general, we might say that the poorer the state, the harder it struggles to give museum educational service.

If we classify the natural history museums according to type, they may be listed as metropolitan, provincial, college and private museums. The college museums are dominant in numbers, having increased steadily since the institution of the first one in 1705 at the College of William and Mary. However, the provincial museums are somewhat more active than the college museums. The metropolitan museums are more active in all lines than other types of museums, but they are fewer in numbers. There are nearly twice as many college museums as provincial museums, 10 per cent. of them being in New York State, 9 per cent. in Massachusetts and 9 per cent. in Michigan. The location of colleges in the United States has helped to locate museums in sections of the country where otherwise museums might not be situated, and may have given rise to the statement that "museums are most frequently found in sections of highest culture and enlightenment." It can not be questioned that museums are considered a valuable part of a college, since colleges lead in supporting natural science museums at least.

The financial support of museums is derived most commonly from taxation, state museums deriving their income almost entirely from this source. Endowment stands second as a source of income, half of the museums being partly supported by this method; and a very few museums are supported by membership dues.

Exhibition forms the chief activity of over 90 per cent. of the museums and is the principal method of conveying knowledge. This and research are the principal activities of state museums. While research is dominant in college museums, popular lectures are most noticeable in provincial museums. Private museums do the least amount of research. In general, more emphasis is placed on disseminating knowledge than increasing it. Extra-mural activity or school service is a lesser activity of museums but is rapidly becoming recognized as an important part of their work.

This investigation of conditions among the natural science museums of the United States is not without its limitations because of slowly changing conditions, the general nature of the quality and amount of the

various museum activities, the original source of wealth and many other unknown facts; but it may be assumed that the data, even though obtained by questionnaire, give a fairly reliable picture of average conditions.

EDWARD J. FOYLES
UNIVERSITY OF ROCHESTER

BLOOD PRESSURE OF TYPHOID CARRIERS

IT has been known for years that typhoid carriers are very likely to exhibit signs and symptoms of gall bladder disease. Carriers submitting to cholecystectomy, whether because of clinical symptoms or to protect the public health, almost invariably have cholecystitis and, if the infection has been of long standing, cholelithiasis.

It has recently been found in Michigan that a chronic typhoid carrier of long standing is more likely to have hypertension than a person of the same age in the general population. The arbitrary limit of normal systolic blood pressures is frequently placed at 140 mm, and in Symonds's tables[1] the mean systolic pressure even for those over 60 is but 135.2 mm, if the 5.7 per cent. who had systolic pressures above 140 mm are excluded. On the other hand, of 40 carriers of long and short standing, 55 per cent. had a systolic pressure above 140 mm, the mean systolic pressure of the group being 155 mm. An elderly group of 27 persons in a county home, many of whom had arterio-sclerosis, had a mean systolic pressure of but 145 mm, whereas 27 carriers with the same mean age had an average pressure of 175 mm. In the 11 carriers who had had typhoid fever before 1911, the lowest systolic pressure was 158 mm and the mean 197 mm.

We are not prepared to evaluate as yet the relative importance of age and the age at which the person becomes a carrier, nor has our experience been great enough to draw any conclusion as to relative longevity. If our observations are representative, it would seem that a typhoid carrier does not have as great a life expectancy as a person of the same age in the general population.

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LANSING

THE SPECTRUM OF DEUTERIUM?

IN a paper in *The Astrophysical Journal* of July, 1918 (Vol. xlviii, p. 10), entitled "The Astronomical Atom and the Spectral Series of Hydrogen," the present writer undertook to calculate the value of the nuclear charge of the hydrogen atom from the wavelengths of the lines in its different spectral series. From these computations he concluded that the "principal series" of hydrogen must be due to an atom having twice the nuclear charge of the atom of the Balmer series. He says:

> It would seem that it must be possible to have a hydrogen atom with a nuclear charge of $2e$. Such an atom should give off radiation of higher frequency than one with a charge only half as great, and its spectrum should be looked for in the ultra-violet.

In SCIENCE of July 13, 1934 (p. 23), Lord Rutherford says that double weight hydrogen has been prepared of such purity that the Balmer lines are not visible in its spectrum, but does not mention the lines of the principal series.

FERNANDO SANFORD
PALO ALTO, CALIF.

BERL ON NATURAL OIL

IN a recent number of SCIENCE[1] appeared an article by E. Berl, of the Carnegie Institute of Technology, entitled "Origin of Asphalts, Oil, Natural Gas and Bituminous Coal." The present writer is concerned meanwhile only with the short closing paragraph of the article. There one reads: "The so-called animal theory, which explains the formation of oil by the heat decomposition of fish, and the lignin theory, which assumes that bituminous coals are derivatives of lignin, can not be substantiated by experiments."

To any one at all familiar with the history of petroleum and its possible primary origin, alike on a colossal scale in nature, and on a small scale experimentally, the first part of the above assertion betrays a serious ignorance on the part of its author. For it should be known to all who have given any attention to the subject that the two eminent investigators, Professors Warren and Storer, published in 1867[2] a striking and suggestive paper, which has been too much neglected in recent years by investigators.

A condensed account of their experiments was published by the present writer some years ago,[3] and reads as follows: "We owe the first exact and definite proof that fish oil can be converted into secondary products like those of petroleum and its derivatives, to the careful researches of Warren and Storer. To some prepared milk of lime they added a quantity of commercial menhaden oil in a wooden tub, at the bottom of which was a coil of perforated pipe that introduced steam. Saponification was effected in a few hours, and the saponified mass was dried. It was then strongly heated with hydrate of lime in a retort, when

[1] *Jour. Am. Med. Assn.*, 80: 232, 1923.

[1] September 7, 1934, page 227.
[2] Amer. Acad. Arts and Sc., Memoirs," S2, 9, page 177, 1867.
[3] "Fishes the Source of Petroleum," page 21, Macmillan Company, 1923.

distillation proceeded quietly and regularly. The distillate consisted of 'a mixture of hydrocarbon oils, of a dark brown color, and a peculiar disagreeable odor.' In consistency, 'this mixture did not differ much from the crude coal-oil which is obtained by distilling rich cannel coals.'

"'The crude hydrocarbon oil was rectified by first distilling it in a slow current of steam, then treating the distillate successively with oil of vitriol and a solution of caustic soda in the usual way, and again distilling in steam as before. The refined product so closely resembled refined coal-oil and petroleum in odor, color, and illuminating properties, that it could hardly be distinguished from these.'

"The crude oil thus secured was distilled, and a naphtha, 'a mobile liquid of light, lemon yellow color, and peculiarly nauseous odor,' was obtained. From this in turn, on repeated distillation, a series of sixteen bodies with definite but different boiling points and specific gravities, separated out. These included benzol, toluol, xylol and other now well-known hydrocarbons, that are derived from destructive distillation of crude petroleum. They further were able to compare these results with a similar series secured from like study of Rangoon petroleum.

"Warren and Storer therefore deserve fullest credit for thus blazing the way in a skilful manner, toward a true explanation of the evolution of many hydrocarbon products from their primitive source, namely fish-oil."

The present writer would now ask Mr. Berl: "Does he, or does he not, consider that the above experimenters carried out the series of experiments as described, and if so does he accept their results as explaining in a satisfactory manner the possible origin of petroleum and numerous related chemical bodies from "the heat decomposition of fish"?

But many years after publication of their results, Engler experimented with the same fish-oil and concluded that such is capable of yielding large supplies of petroleum. Still more recently investigators in this and other countries have shown that production of petroleum from fishes can "be substantiated by experiments." The present writer then fully accepts and defends the correctness of his aphorism, "Fishes the Source of Petroleum." For unless Berl or others can prove that the colossal supplies of free oil already utilized, shamefully wasted or still in natural storage can be clearly traced to some other and natural source, he is compelled to adhere to the truth of the above aphorism.

JOHN MUIRHEAD MACFARLANE

SOCIETIES AND MEETINGS

THE SECOND ALL-SOVIET MATHEMATICAL CONGRESS

FROM June 24 to 30, 1934, there took place in Leningrad the second All-Soviet Mathematical Congress, the first of which was held in Kharkov (Ukraine) in 1930. The sessions met in the buildings of the Academy of Sciences of the U.S.S.R. and of the University of Leningrad. This is an imposing and historical group on the right bank of the Neva facing the center of earlier court and administrative activities (Winter Palace, Admiralty, St. Isaac's Cathedral) on the other bank. There were nearly six hundred delegates from all institutions of learning of the U.S.S.R., but the undersigned was the only non-Soviet participant. Some 230 papers were presented in the nine sections (algebra and number theory, geometry, topology, analysis (2), mathematical physics, probabilities, approximations, history and philosophy of mathematics) and, in the plenary sessions, the following addresses were given by invitation:

I. M. Vinogradof, "Waring's Problem."
P. S. Alexandrov, "The Relations between Algebra and Topology."
V. I. Smirnov, "Certain Contributions of the Leningrad School in Analysis and its Applications."
A. O. Gelfond, "The Theory of Transcendental Numbers."
N. G. Tchebotarev, "Certain Problems of the Modern Galois Theory."
V. V. Stepanov, "Quantitative Methods in the Theory of Differential Equations."
L. A. Lusternik and L. G. Schnirelmann (presented by the former), "Topological Methods as Applied to Problems of Extremals."
L. S. Pontrjagin, "Structure of Continuous Groups."
M. A. Lavrentiev, "Geometrical Questions in the Theory of Functions of Complex Variables."
N. M. Gunther, "Stieltjes Integrals in Mathematical Physics and in the Theory of Integral Equations."
I. M. Muntz, "Functional Methods in Boundary Problems."
S. Lefschetz, "Algebraic Geometry: Its Methods, Problems and Tendencies."
A. N. Kolmogorov, "Certain New Tendencies in the Theory of Probabilities."
I. A. Kibell, "Mechanics of Compressible Fluids."

The general level of papers presented and lectures given was of the highest. The formal lectures were attended by hundreds of auditors, even though several were usually given simultaneously, owing to shortage of time. One day was devoted to a discussion of

the work of the mathematical institutes and to an examination of the prospective development of mathematics in the Soviet Union. In this field of endeavor as in others there may be observed in the U.S.S.R. a strong tendency towards a planned and guided action.

The social features were not neglected, and there were interesting excursions to the former palatial country residences of the Czars and to the Islands. There were also all possible facilities for personal contacts and exchanges of views between the delegates in the social rooms of the Academy, of the Club des Savants, or during walks through Leningrad, which is most attractive in late June, the season of the famous White Nights.

The very high distinction reached by Soviet mathematics was fully reflected in the congress. The development of mathematics in the U.S.S.R., as in the United States, has largely been a matter of the last two generations. The majority of the delegates were young, many of them in the twenties. The common tone of optimism was also striking. While savants in the Union do not live as comfortably as their colleagues in the West, nevertheless they are very highly esteemed and treated accordingly. There are several mathematical institutes whose chief purpose seems to be to support a certain number of part or whole-time research professors, thus largely freeing the more capable men from routine teaching duties. Owing to the transfer of the Academy of Sciences to Moscow which has just taken place, there are now in the capital two first-rate mathematical research institutes—the Steklov Institute of the Academy, directed by Vinogradov, and the Institute of the University, directed by Kolmogorov. Moscow is thus more than ever one of the world's greatest mathematical centers. However, the encouragement given by the Soviet government to the cultural development of national groups is providing a healthy counter-balancing influence to excessive scientific centralization. We may therefore confidently look forward to the development of new scientific centers in entirely new localities and to the further growth of the older groups.

S. LEFSCHETZ

PRINCETON, N. J.

THE FIFTH CONGRESS OF THE INTERNATIONAL FEDERATION OF SURVEYORS

THE fifth congress of the International Federation of Surveyors was held in London, England, from July 18 to 21. There were present 346 delegates from 21 countries, the United States being represented by Colonel James Gordon Steese and the writer.

This brief report is prepared with the thought that some American engineers may be interested in the proceedings of this conference. It is necessary, however, to confine these remarks to the discussion at the meetings of the committee on improvements in instruments and methods in surveying, one of the five technical committees into which the entire congress was divided.

Papers were presented at the meetings on many subjects concerning instruments and methods. The open discussions, however, were confined to two topics which were considered of the most outstanding importance, namely: (1) The polar coordinate method for locating details in cadastral surveying, with special attention to the methods for measuring distances; (2) The use of aerial photogrammetry in cadastral surveying.

The committee recommended the use of the polar coordinate method for locating details in cadastral surveying, in preference to the rectangular coordinate or offset method. This is doubtless entirely in agreement with present practise in this country, for surely with the adoption of more modern methods of cadastral surveying American engineers are using the polar coordinate method very extensively. Both its advantages in most cases and its occasional limitations are familiar to all American surveyors.

However, the discussions of the methods for measuring distances are noteworthy. It is rather astounding to an American surveyor to find that in continental Europe the use of tapes for measuring distances in cadastral surveys is virtually superseded by the double-image tacheometer. Delegates at the congress agreed that the improved double-image tacheometers now manufactured in Europe were capable of measuring distances up to 140 meters with an accuracy of one part in 5,000, the modern tacheometers even being equipped with ingenious devices for reading directly horizontal instead of inclined distances. The committee recommended the extensive use of this instrument in cadastral surveys. Inasmuch as the method is at present seldom used in the country, this recommendation indeed deserves the attention of American surveyors.

Although it is understood that aerial photogrammetry is entirely inadequate under some circumstances in cadastral surveying, the discussion by the committee indicated their complete accord regarding the adaptability of the method in many cases. They recommended the method for use in cadastral surveying extensively but not exclusively. On account of the skepticism still existing among American surveyors regarding the resources of aerial photogrammetry, there is considerable significance in this recommendation, for it must be remembered that cadastral surveying is rather a severe test for the precision of the method and that this recommendation is made by a committee consisting largely of European engi-

neers who are familiar with the use of the stereoscopic plotting instruments for photographic mapping.

These, then, are briefly the conclusions reached by the congress of the International Federation of Surveyors regarding what were considered as the two most outstanding topics in the field of improvements in the instruments and methods of surveying.

EARL CHURCH

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

BUTYL ALCOHOL AND CYTOLOGICAL TECHNIQUE

SEVERAL years ago the writer[1] described the advantages of *n*-butyl alcohol in dehydration and clearing specimens for paraffin embedding. Hemenway,[2] Earl,[3] LaCour,[4] Waterman[5] and Stiles[6] among others have extended and modified the technique so that now *n*-butyl alcohol is used in preparing many different types of material for embedding, and most cytological laboratories have a supply on hand. The purpose of this note is to call attention to some minor uses that can be made of this reagent.

A fluid composed of two parts of ethyl alcohol and one of butyl can dissolve both water and xylene and keep them in solution at the same time. Thus a mixture of

water	1 part
xylene	1 "
n-butyl alcohol	1 "
ethyl alcohol	2 "

forms a single clear liquid. This solution is useful for cleaning slides as it will soften and remove both water-soluble substances (glycerine, glucose, etc.) and those which are fat soluble (immersion oil, balsam, etc.). Dilute ammonium hydroxide can be substituted for the water and carbon-tetrachloride for the xylene. This latter combination forms a very potent cleanser.

Another and perhaps more useful application of *n*-butyl alcohol to the cytological technique occurs in the hydration and dehydration of cut sections. The usual procedure is to place the slides containing the paraffin ribbons into a Coplin jar filled with xylene. When the paraffin is dissolved, the slides are transferred to absolute ethyl alcohol and then through several successive dilutions of alcohol to water. When the sections are stained they are passed back through the series of Coplin jars and mounted in balsam. Unfortunately, some xylene adheres to the slides and is carried on them into the absolute alcohol, where it soon appears as a milky precipitate as the alcohol absorbs moisture from the air. Likewise some alcohol and water are carried into the xylene, which also becomes clouded. In the moist atmosphere of seaside laboratories it is particularly difficult to prevent water from contaminating the absolute alcohol and the xylene. A few drops of *n*-butyl alcohol, however, added to these clouded fluids will clear them immediately, as the butyl alcohol will take both water and xylene back into solution. If the original series is made up as follows, no precipitate should occur.

(1) xylene 100 per cent.
(2) xylene 95 per cent., *n*-butyl alcohol 5 per cent.
(3) absolute ethyl alcohol 90 per cent., *n*-butyl alcohol 10 per cent.
(4) absolute ethyl alcohol 100 per cent., etc.

The writer has often passed more than a hundred slides through a single series of Coplin jars without renewing any of the solutions or obtaining any precipitate.

CONWAY ZIRKLE

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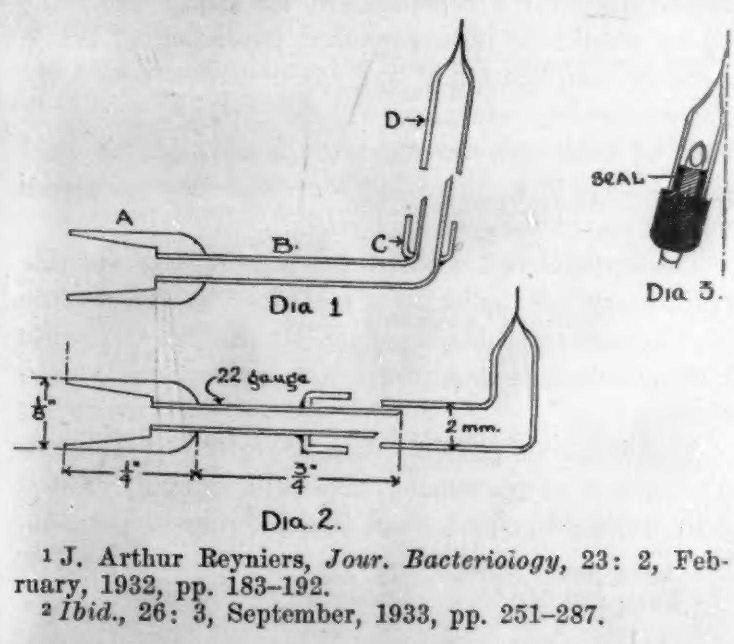
[1] SCIENCE, 71: 103–104, 1930.
[2] SCIENCE, 72: 251–252, 1930.
[3] SCIENCE, 72: 562, 1930.
[4] *Jour. Roy. Mic. Soc.*, 51: 119–126, 1931.
[5] *Stain Tech.*, 9: 23–31, 1934.
[6] *Stain Tech.*, 9: 97–100, 1934.

A MICROPIPETTE ADAPTER

MICROPIPETTES used for single cell isolation and dissection can be made from capillary glass tubing on a machine designed to pull them to a certain size.[1] Mechanically made pipettes require a special mounting or adapter before they can be used satisfactorily in a manipulator. Once mounted, however, they offer the advantages of being in a certain position and can be easily changed.

The adapters described herein are improvements over devices previously described.[1, 2] Diagram 1



[1] J. Arthur Reyniers, *Jour. Bacteriology*, 23: 2, February, 1932, pp. 183–192.
[2] *Ibid.*, 26: 3, September, 1933, pp. 251–287.

shows the bent type of adapter used principally in single cell isolation. It consists of a base (A) made to screw or slip on a manipulator mounting; a piece of 22 gauge hypodermic needle wire (B) 1 inch long bent to less than 90 degrees ¼ inch from its end and sharpened to a bevel; a cup (C) large enough to admit a piece of capillary tubing which will fit over the needle; (D) represents a micropipette. In use the cup may be filled with wax, vaseline or some other sealing substance or it may be empty, depending on the pressure to be exerted in exhausting the pipette of fluid. The pipette is warmed before use and is slipped over the adapter end into the cup. The sealing substance in the cup makes a perfect seal.

The adapter described in Diagram 2 is essentially the same as the one described in Diagram 1 as to dimensions and construction, except that it is not bent at one end but is allowed to remain straight. This type of adapter is used in micro-injection experiments where a relatively large volume of fluid is to be handled. The pipette shank can be made to any length. The pipette must be sealed in with cement or sealing wax to prevent it from turning.

Diagram 3 shows an end view of an adapter and pipette in place. It illustrates how the pipette must be turned to allow the light to strike its tip rather than the metal adapter.

These adapters are made for me by the South Bend Watch Service, South Bend, Indiana, and have been in use for over a year.

J. A. REYNIERS

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SPECIAL ARTICLES

THE ENERGY REQUIREMENT OF AN ACROMEGALIC GIANT

DURING the spring of 1933, the author had the privilege of studying the gaseous exchange of a group of pituitary cases who were in Boston on a professional engagement. The results have been reported[1] and showed a marked lowering in the energy requirement of all the dwarfs. The results with the giant in the group (J. E.) were recognized and reported as unsatisfactory at the time of testing. At an earlier date, a measurement had been attempted with this subject elsewhere, using a small portable apparatus, the oxygen content of which was speedily exhausted with somewhat disturbing results. While our own approach utilized the open circuit method with large Tissot containers, a certain apprehension, residual from his previous experience, precluded the attainment of that tranquility essential for accurate measurement. His return to Boston this spring gave opportunity for a repetition of the study under the better conditions of a corrected psychology. While a fairly complete study was again carried out,[2] only the respiratory exchange will be reported here. It may be said, however, that the results of the 1934 studies showed a surprisingly precise correspondence with those of the previous year.

The open circuit method was again used, and the respiratory metabolism was measured by Dr. Thorne M. Carpenter and his associate, Mr. Robert C. Lee, to both of whom it is a pleasure to express my appreciation.

The orienting physical data are given in Table I. The height measurement implies a growth of one inch during the past year, which I am disposed to question. The subject had been spending the winter in the South and was in definitely better physical condition than when previously studied. I attribute his apparent gain probably to a more erect carriage and am supported in some degree by the fact that the span dimension remained unchanged. On the other hand, the sitting height failed to show the increment that would accord with this hypothesis; posture, however, plays a significant rôle in this measurement. The other data show a gratifying concordance.

The respiratory data are shown in Table II.

TABLE I
DIMENSIONS

Datum	1933	1934
Standing height (cm)	228.6	231.1
Span (cm)	236.2	236.2
Sitting height (cm)	110.5	111.2
Index	0.483	0.481
Chest (cm)	124.3	123.2
Waist (cm)	107.0	106.7
Weight (kg)	163.3	162.7
Area (sq. m.)	3.125	3.236

TABLE II
OXYGEN CONSUMPTION

Datum	1934		1933
Respiratory quotient	0.806 0.800	0.803	0.890
Oxygen, per minute	356.2 cc 358.7 cc	357.5 cc	419.7 cc
Energy, per 24 hours	2,466 Cal. 2,480 Cal.	2,473 Cal.	2,969 Cal.

[1] Rowe, *Jour. Nutr.*, 7 573, 1934.
[2] Rowe and Mortimer, *Endocrin.*, 18: 20, 1934.

The respiratory quotient in 1933 was one of the indices pointing to a lack of basal conditions. In addition, the systolic blood in the present series was 126 mm as against an earlier level of 146 mm, while the diastolic pressure was unchanged at 90 mm. The earlier pulse rate was 78; during the present study, 80 was recorded, a value in harmony with other independent measurements during both sets of observations.

Comparison of the observed rate with our usual prediction standards is given in Table III.

TABLE III

RELATIVE DEVIATIONS

Standard	1934 Pred.	1934 Dev.	1933 Pred.	1933 Dev.
		Per cent.		Per cent.
Harris-Benedict[3]	3,277	-24	3,279	-9
Boothby[4]-Aub-DuBois[5]	3,130	-21	3,110	-5
Average		-23		-7

The present figures demonstrate a frank depression of the basal rate to a level consonant with the subject's known pituitary status.

But one point remains for brief consideration. DuBois[6] called attention a number of years ago to the fact that febrile temperatures cause a definite and rather uniform increase in the oxygen exchange, the coefficient being of the order of +7.2 per cent. per degree Fahrenheit. During the test of 1933, the subject's oral temperature was 98.6°, while in that here reported, the more characteristic level of 96.8° was observed. Allowance for the temperature difference on the above basis would lower the 1933 average to -22 per cent. Whether his earlier instability produced an augmentation of temperature, as it certainly did of systolic blood pressure and pulse rate, is a question. Oral temperatures are well known to lack a nice precision as indices of the mean body temperature. Whatever the mechanisms involved, there can be no question but that the present measurements are much more nearly representative of the subject's energy exchange and demonstrate an established level of hypofunction.

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[3] Harris and Benedict, *Carn. Inst. Pub.* No. 279, 1919.
[4] Boothby and Sandiford, *Jour. Biol. Chem.*, 54: 767, 1922.
[5] Aub and DuBois, *Arch. Int. Med.*, 19: 831, 1917.
[6] DuBois, *Jour. Am. Med. Ass.*, 77: 352, 1921.

THE DETERMINATION OF CO_2 IN THE ATMOSPHERE OF A CLOSED SYSTEM[1]

IN a recent note[2] Elizabeth M. Smyth described methods of determining the CO_2 content of an atmosphere in a closed system. These methods were based on the estimation of pH in a solution of $NaHCO_3$ plus a suitable indicator.

The thermal conductivity method offers distinct advantages for determinations of CO_2 content in closed systems, since this method is capable of high accuracy, as well as being both rapid and convenient in use, and it is believed that a brief statement of important references on the method will be of interest to workers in many fields of investigation. The fundamental principles involved are well described in various sources.[3] The method has been applied to the determination of CO_2 concentration in greenhouse atmospheres[4] and has also been used for the analysis of expired air.[5] H. A. Daynes has used the thermal conductivity device for the study of respiration in small insects,[6] and determinations of CO_2 in leaf respiration in the dark and assimilation in the light have been made by J. C. Waller.[7] A further development of the method was used in a research on the effect of manurial deficiency on the respiration and assimilation rates in barley.[8] H. A. Daynes has described a simple experiment in which a seed, such as a bean, is allowed to germinate in a small chamber attached to one tube of a thermal conductivity cell. A steady increase in CO_2 in the chamber is noticeable in a few minutes. If the chamber is immersed in ice, the increase practically ceases, but is resumed as the seed warms up after being taken out of the cooling vessel.[9]

Attention is called to the utility of the method because of its numerous advantages. The absolute accuracy can be of the order of ± 0.01 per cent. of CO_2 in concentrations up to 5 per cent. Readings can be

[1] Communication from the Research Laboratory, Leeds and Northrup Company, Philadelphia, Pa.
[2] SCIENCE, 80: 294, 1934.
[3] P. E. Palmer and E. R. Weaver, Technologic Paper of the Bureau of Standards No. 249, 1924; also "Gas Analysis by Measurement of Thermal Conductivity," by H. A. Daynes, Cambridge Press, 1933.
[4] C. Z. Rosecrans, *Jl. Optical Soc. and Rev. Sci. Instruments*, 14: 479, 1927.
[5] A. K. Noyons, *Arch. Néerland. physical.*, 7: 488, 1933; also P. G. Ledig and R. S. Lyman, *Jour. Clin. Invest.*, 4: 495, 1927; also H. W. Knipping, *Zeits. physikal. Chem.*, 141: 1, 1924.
[6] H. A. Daynes, *Proc. Physical Soc.*, 37: 349, 1925.
[7] J. C. Waller, *New Phytologist*, 25: 109, 1926; also 28: 291, 1929.
[8] F. G. Gregory and F. J. Richards, *Ann. Bot.*, 43: 119, 1929.
[9] H. A. Daynes, *Jour. Soc. Chem. Ind.*, 45: 8, 1926.

taken in less than one minute after the apparatus is filled with the gas to be analyzed. The atmosphere analyzed is in no way changed by the process of analysis, and no solutions are required. Continuous indicating or recording of CO_2 concentration is possible in some cases where extreme accuracy is not required. It is possible in such cases to control automatically the CO_2 concentration at any desired value by the use of a thermal conductivity cell together with an electrical recorder-controller of a commonly used variety.

A thermal conductivity apparatus of general laboratory utility can easily be assembled from standard laboratory electrical equipment, following descriptions in various references already cited. A useful apparatus for general use was described by the writer.[10] While designed particularly for the determination of fuel gas/air ratios, it can be used for many thermal conductivity measurements of high accuracy by substituting a high sensitivity reflecting galvanometer for the less sensitive pointer galvanometer.

CRANDALL Z. ROSECRANS

THE AXIS OF THE HUMAN FOOT

PREVIOUS workers on the human foot have held divergent views concerning the position of the axis of the foot. Attempts have been made to compare the human foot with that of even-toed forms, in which the axis lies between the second and third digits, or with the odd-toed types, with the axis coinciding with the third digit. The latest view is that of Morton,[1] which maintains that the functional axis of the foot of the human and of apes differs from that of other mammals in that it lies between the first and second digits.

No doubt the difficulty of determining the axis of a structure as complicated as that of the human foot is responsible for this confusion. The position of the axis of the ungulate foot can be ascertained by sheer morphological observation. With the human foot such observation has led to no definitive solution of the problem.

Fortunately, it is now possible to determine the position of the axis of the human foot by experimental procedure. Recently one of us[2] published a description of a new method by means of which the distribution of pressure in the human foot at any instant can be recorded cinematically as a pattern of dots, the area of the dot varying with the pressure being exerted. For details of the method and samples of the results the original article may be consulted. We have now calibrated the variation in area of dot with variation in pressure. By the method of moments it has been possible by extensive calculation to determine, for the step illustrated in Fig. 2 of the article mentioned, the position of a resultant force having the same effect as the various discrete pressures recorded.

The position of this resultant must lie on the axis of the foot, if the axis, as is usually considered, represents the line of functional symmetry of the foot. It would be more accurate to refer to a plane of symmetry and to say that the resultant lies in the line of intersection of this plane with the horizontal.

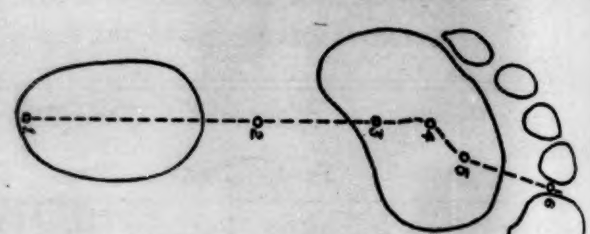

FIG. 1

The accompanying diagram (Fig. 1) illustrates the position of this resultant at successive moments in the course of one step, the path of the resultant being indicated by a dotted line. The position of the axis at any moment can be approximately determined by drawing a tangent to the dotted line through the position of the resultant at the moment under consideration.

Until the step is half completed, the axis passes through the center of the heel and along the medial border of the third metatarsal. As the heel is lifted and the metatarso-phalangeal joints dorsi-flexed, the axis becomes directed definitely inward, at the conclusion of the step lying between the first and second digits. By visualizing the successive positions of the foot in space, it is possible to follow the changes in position of the axial plane.

The position of this functional axis varies with the degree of toeing in or out and may very well vary with the structural condition of the foot. A comparison of the human foot with that of the chimpanzee is nearing completion. A detailed report of our findings will be published as soon as supplementary measurements by another method have been accomplished.

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[10] C. Z. Rosecrans, *Ind. Eng. Chem., Anal. Ed.*, 1: 156, 1929.

[1] D. J. Morton, *Jour. Bone and Joint Surgery*, 6: 56–90, 1924.

[2] H. Elftman, *Anat. Rec.*, 59: 481–491.

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